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ABSTRACT

The concept model addressed in this paper is the set of assumptions, data, and inferences used in the instructional design of concept learning. A new way of looking at concepts is presented that takes into account the declarative and metacognitive components of concept learning and use. Implications for instruction are outlined. The paper is largely a response to traditional concept teaching models that focused nearly exclusively on the procedural components of concept use. with Robert Gagne's (1985) taxonomy of learning outcomes serving as an example, it is recommended that the "intellectual skill" of concept using be re-married to the "verbal information" that makes the concept meaningful. It is noted that concepts taught in this broader way will be more likely to be used in realistic performance situations. A continuing effort needs to be made to study strategies such as simulations, scenario-based instruction, and case studies that can help concepts come alive to beginning learners. (JD)

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A New Model

of

Concept Teaching and Learning

Paper presented at the annual meeting of the
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Running head: CONCEPT MODEL

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I. Introduction

Because the title of this paper suggests a new model, we should perhaps first explain what we mean by "model." A second implication of our title is to outline an "old" model of concept learning/teaching. We will do both these things to start the discussion.

Webster's 7th New Collegiate Dictionary defines "model" as a system of postulates, data, and inferences, prepared as a description of a state of affairs (1965). In particular, the concept model we address is the set of assumptions, data, and inferences used in the instructional design of concept learning. Components of this design model include assumptions about:

- o the nature of concepts
- o the way concepts are learned
- o how concept learning is measured
- o how concept learning should be designed.

This paper will explain how, in light of recent concept learning research and theory, each of these design model aspects warrants revision, creating a new model of concept learning.

II. Aspects of Current Design Models

1. The nature of concepts. Several design theorists explain that concepts are types of classifying rules (R.

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Anderson, 1973; Gagne & Driscoll 1988; Gagne, Briggs & Wager, 1987) that are used to facilitate the classification or identification of instances (Reigeluth et al, 1978; Klausmeier, 1980). Definitions, attributes, and examples are acquired to facilitate this process. Concepts can be divided into two broad categories, concrete and defined (Gagne & Driscoll, 1988)

2. How concepts are learned. Concepts are stored as declarative and procedural components of a networklike arrangement in long-term memory. Some theorists see concepts as nodes in a network (J.Anderson & Pirolli, 1984), while others see concepts as slots of a broader schema (Gage & Berliner, 1988). Concepts have often been shown to be members of a "kinds" or "parts of" hierarchy of class relationships. In each case, concepts are seen as subsidiary components of larger structures of stored information.

3. How concept learning is measured. Consequent with the nature of concepts, concept learning is measured by learners' ability to recognize instances of the concept. Learners generalize across examples and discriminate from nonexamples (Tennyson & Park, 1980). To this end, Tennyson and his colleagues have developed methods of diagnosing practice and test items that facilitate concept classification and acquisition (Park & Tennyson,

1980; Tennyson et al, 1985). The history and rationale for classification measures dates to the time of Hull in the 1920s, when classifcation criteria were used for some of the first laboratory experiments in concept learning.

4. How concept learning is designed. The primary mode of concept teaching centers around the presentation of a definition or defining attributes, with a presentation of examples and nonexamples, followed by practice in classifying examples/nonexamples (Tennyson & Cochiarella, 1986). In addition, presentation strategies such as attribute isolation and mnemonics aid learning of declarative knowledge such as concept definitions (Reigeluth et al, 1978), while the selection and sequencing of practice examples develops procedural skills in generalization and discrimination (Tennyson & Park, 1980; Driscoll & Tessmer, 1985).

Today, much instructional design in concept learning proceeds with most or all of the preceding assumptions implicit. This is true in business and military settings as well as K-12 education (Joyce & Weil, 1985; Hunter, 1983). However, current research, particularly in cognitive science, points to new conceptions of the nature and acquisition of concepts, and to how to measure and teach concepts. As we discuss in the next section, concepts are learned and used for more than

classification, and should be taught through interventions that develop these non-classificatory uses.

III. Departures from the Traditional Concept Model

1. The nature of concepts. Concepts should not be defined as classifying rules, but as **categories that serve as cognitive tools.** A concept is more than the rule used to find its members. Indeed, defining a concept merely as a classification rule is like defining theory as rules for theorizing, or procedure as step-following. As Brown et al (1989) indicate, conceptual knowledge is more like a set of tools that are used for different contextual purposes, as opposed to abstract definitions. Researchers such as Klausmeier (1980) have explained that the uses of a concept involve more than classification. Epistemologists such as Pollock (1974) have long held that understanding the meaning of a concept means understanding its uses. Certainly, concepts are still ideas, but the function of conceptual knowledge in and of itself transcends example classification.

2. How concepts are learned. Concepts have both declarative and procedural components, and as such need instruction suiting both declarative and procedural learning outcomes. Declarative strategies typically seek to make the information surrounding the concept

personally meaningful to the learner (cf. Reigeluth, 1983), such as explaining the origin of the concept or providing a mnemonic to help recall a definition. Procedural strategies, such as repeated practice with response-sensitive feedback, are aimed at producing accurate and easy performance of concept-related skill (Salisbury, Richards, Klein, 1985).

Over time, a concept may become a schema or network itself, instead of a node or component of one. In many cases, concepts such as "giftedness", "cost-benefit analysis" or "glasnost" may have an enormous amount of declarative and procedural knowledge attached to them, what philosophers refer to as semantic and emotional "baggage", or what Carroll (1964) has called the cognitive and affective components of concepts. Such concepts are not so much learned through definitions as acquired over time (Brown et al, 1989) through use and experience.

Moreover, the way that these conceptual tools are used depends upon the context of use (Whitehead, 1954; Carroll, 1964; Barsalou, 1985), so that learners acquire declarative and procedural knowledge for specific settings iin which they use it. As knowledge is acquired about the concept, learners themselves infer further knowledge about the concepts (Camp et al, 1980, Lehrer &

Koedinger 1988; Naveh-Benjamin, et al, 1986). Thus, a single concept in memory may eventually contain a definition or defining attributes, examples and nonexamples, procedures of classification/identification, connections to related knowledge, emotive connotations, and rules for use in certain contexts. In this sense, a concept seems to become more like a schema (Slavin,1986; Howard, 1988) in the way information is organized around a single theme, the concept name.

The database on a single concept can be "rich in content and complex in form" (Tversky, 1977, p.329) or "encyclopedic" (Shavelson, 1974, p.236). Most important for instructional design, the uses of a concept and its connection to related knowledge are part of its makeup, and must be measured and taught. Failure to teach these additional elements could lead to students who can classify cases in a rote way, but cannot make genuine use of the concept in problem-solving situations.

3. How concepts are measured. Traditionally, concepts have been measured by means of concept classification or identification tasks. This kind of measure certainly suits training tasks such as tank identification or laboratory tasks such as dot pattern recognition, but are there other valid measures of "really understanding" a concept?

To answer this question, we surveyed 48 graduate students from two different classes (one in introductory educational psychology and the other front-end analysis), and asked what "really" learning certain concepts meant to them. Each graduate student was given a two-page handout describing a scenario in which he or she was teaching a sophomore class of medium to above average intelligence, who knew nothing about the concepts to be learned. For each concept, room was provided to list and describe performance measures indicating learning of that concept. The three concepts surveyed were "glasnost", "snow leopard", and "justice". Almost none of the students had any background knowledge in instructional design. The purpose of this exploratory study was to get an idea of the "mental models" people have when they talk about learning a concept. Our preliminary findings are summarized in Table 1.

Insert Table 1 about here.

The results of the study indicate that, at least to graduate students in education, a whole array of activities may be appropriate indicators of concept learning in addition to concept classification. Perhaps the most salient finding is the prominent role of

declarative knowledge. Students who can define, describe, give examples, and relate the concept to other knowledge are demonstrating their learning of the concept. We would claim that students who cannot do these things may have a deficit in their understandings that will inhibit meaningful encoding and creative use of the concept.

Two concept performance measures surfaced that reflect "higher" kinds of cognitive activity: using a concept (e.g., writing stories, skits, sentences) and generating inferences about a concept (e.g., theorizing, drawing implications, understanding context). These uses and inferences reflect a conceptual-tools view of concept learning, where the inferences drawn from concepts (J.Wilson, 1971; Shavelson, 1974; Smith & Medin, 1981) and the uses of the concept (Markle, 1975; Brown et al, 1989) are part of the purposes and determinants of concept learning. To say that these measures are not valid because concepts are classification rules is to beg the question and ignore the learning goals of instructors and educators.

How can concepts be measured through use? Our survey indicated several possibilities, some of which are echoed by other researchers:

1. Using the concept in conversation, writing, and argumentation: to communicate intelligently with about the concept (Brown et al, 1989).
2. Role-playing or simulating the concept (Tessmer et al, 1989). What would it be like to be a snow leopard, to dispense justice)?
3. Making judgments or criticisms on the basis of the concept.

In all cases, the emphasis is on the use of the concept as a tool. Students learn the defined concept "justice" not just to identify examples of justice and injustice, but to employ the concept intelligently.

The use of concepts for inferences was not as readily identified by respondents, which may be due to the difficulty in conceptualizing inference measures. Inference-making requires students to spontaneously reason using the concept, making connections between information not previously stored contiguously in memory. In generating inferences, students make associations between things that were previously unassociated or weakly associated. Some inference types are:

1. Inferences about membership of the concept in superordinate categories, since a concept may have numerous superordinate class memberships (R.Anderson & Ortony, 1975). For example, can a chair be a gift?

Is it a form of transportation? Is psychology a science (J.Wilson, 1971)? This type of inference is a measure of alternative conceptions (polysemy) of the concept.

2. Inferences about properties or functions of the concept that are not directly given as defining attributes. For example, can you take a bath in a restroom? If humans are featherless bidpeds, do they necessarily have skin? Does glasnost entail a reduction in armed conflicts between two nations? If canaries can sing, can they breathe (Markle, 1977)? Do basketballs float (Barsalou, 1985)? These examples may seem far-fetched for instruction, yet often people must reason in these ways in order to solve novel problems, whose solution lies beneath the "surface" knowledge they bring to bear on it.
3. Inferences about relationships between other concepts that are at the same level of generality as the target concept, but are not coordinate concepts of the immediate set. For example, does task analysis cause/facilitate/hinder formative evaluation? What does a G-sharp on a piano sound like to you (analogical inference of a concrete concept)? How might the rise of desktop publishing and electronic communications affect scholarly

productivity among faculty?

In addition to the preceding examples, inference questions may also be used to measure conceptual relationships such as causation, proximity, parts, operations and precedence (Collins & Quillian, 1972; Shavelson, 1974; Reigeluth, 1983). These questions also measure the presence and strength of semantic relationships in the concept's network or schema, and elicit learner practice in drawing inferences. The type of inferences elicited during instruction depends on the purposes of the instruction, the prior knowledge of the learner, and the age of the learner, since preadolescents do not generate inferences as readily as older students (Wagner & Rohwer, 1981).

IV. New Methods for Teaching Concepts

To summarize our discussion so far, concepts are more than classification rules and can be schema-like in their construction, and the uses and inferences of concepts are viable measures of concept knowledge. Thus, in many cases concept instruction should be designed to facilitate more than classification performance; to foster the proper schema-like connections with prior knowledge, to encourage inference and use productions. To do this several instructional strategies can be employed:

1. Teaching with analogies. Analogies allow a learner to connect novel conceptual information with their prior knowledge, thus establishing a familiar structure of the new concept. Concept instruction through analogy can be so powerful that that the proper analogy must be carefully chosen (Striley, 1988), and its boundaries (comparatives) to the concept explained (Feltovich et al, 1988).

Several theorists prescribe the use of analogies for defined (abstract) concept learning (Ortony, 1975; Newby & Stepich, 1987). However, analogies can also be used for concrete concepts. This is worth noting since most designers seem to forget that visual/aural/tactile (concrete concepts) can be as complex and/or difficult to learn as defined concepts. Biederman & Shiffrar (1987) present an interesting illustration of this point. They cite an analogy used by chicken sexers, who cultivate their subtle identification skills over years of experience.

2. Use of learning strategies. Various learning strategies can be used to aid the encoding of concept information. Concept mapping and structuring (Jonassen, 1984; Vaughan, 1984; Tessmer and Jonassen, 1988) helps students organize definitions, examples, and properties of concepts, as well as semantic/inferential relations

between other concepts. For classification tasks, advance task instructions on learning and performance expectations can activate concept learning strategies in students (Ellis et al, 1986). If concept inference or use is an objective of the instruction, these advance instructions may help the learner to generate the proper productions for inferences and uses in the concept schema.

3. Use and inference practice. Programs such as the Higher Order Thinking Skills program (Pogrow, 1985) have successfully encouraged students to manipulate conceptual information through creative use, using the concept in various symbol systems to broaden their meanings. For example, using the concept of reinforcement in lab experiments, teaching, and business contexts.

Concept use instruction can proceed through several stages. Learners can begin by paraphrasing the concept definition or attributes (R.Anderson, 1973) and conversing about the concepts (Markle, 1975; B. Wilson & Tessmer, 1989), then move to utilizing the concept in conversations and other communications, and finally to using the concept with other declarative or procedural knowledge to solve problems (B. Wilson & Tessmer, 1989).

For inference instruction, the inference measures outlined in the previous section serve as patterns for

the types of inference practice that can be provided. Students can be provided with learning guidance (context cues) to generate inferences about what is learned (Pogrow, 1985). Indeed, if learners are expected to acquire more than classification performance, guided practice in inference making and/or use must be provided.

4. New strategies for classification performance. A variety of alternate presentation strategies can be used to supplement standard definition-plus-(non)examples strategies for example classification training. Many of these strategies have been advocated by instructional theorists over the years.

For example, displaying coordinate concepts in structural outlines such as concept trees has facilitated coordinate concept classification (e.g. Tessmer & Driscoll, 1986), and may be particularly effective with adult learners (Bower, 1970). For classification practice, concept games and simulations are a little-used strategy that puts the learner into scenarios that elicit classification performance in ways that differ from standard concept example practice (Tessmer et al, 1989). Particularly, concept simulations mimic the real-world situations in which the learner will use concept classification, increasing the probability of transfer. To create concept examples/nonexamples that maximize

generalization and discrimination, the Rational Set Generator (Driscoll & Tessmer, 1985; Tessmer & Driscoll, 1986) can be used to design sequences of coordinate concept examples and nonexamples.

Hierarchical displays facilitate the learning and organization of the declarative component of concept classifying, while rational sets, games and concepts facilitate mastery of the classification skills of concept learning (R.Anderson, 1985; E.Gagne,1985). When used with analogies, use and inference practice, the aforesaid interventions extend what Reigeluth (1983) would call the meaningfulness of the concept.

5. Determing qualities of concepts to be learned. While the distinctions between defined and concrete concepts is a well-established design practice, a more fine-grained analysis of concept qualities could lead to more appropriate instruction. The complexity of the concepts is important. Complexity is determined by the amount and unfamiliarity of information learned to meet concept learning objectives.

Contrary to Newby and Stepich (1987), both defined and complex concepts may be complex and difficult to learn. Concepts may also vary in their precision; many everyday concepts are ill-defined or "fuzzy", defying standard definitional instruction (B. Wilson, 1986). Concepts may

be relational, conjunctive, or disjunctive, each requiring appropriate instructional support. Most important, designers must learn to classify concepts by the content and purposes of the instruction, that the meaning of the concept and its learning objectives frequently depend on these two factors, not on a standard invariant meaning and standard classification performance.

The way people use concepts in context dependent (Whitehead, 1954; Carroll, 1964; Barsalou, 1985). Thus, just as context is examined in a front-end analysis for large-scale instruction, so context should be analyzed when teaching concepts. What are the different uses of the concept by someone who "really understands" it? What are the variable subjects or situations in which it will be used? These are context analysis questions.

V. Conclusion

In this paper, we have presented a new way of looking at concepts that takes into account the declarative and metacognitive components of concept learning and use. Implications for instruction have been outlined. The paper is largely a response to traditional concept teaching models that focused nearly exclusively on the procedural components of concept use. Using Robert

Gagne's (1985) taxonomy of learning outcomes as an example, we are recommending that the "intellectual skill" of concept using be re-married to the "verbal information" that makes the concept meaningful. We believe that concepts taught in this broader way will be more likely to be used in realistic performance situations.

The obvious danger in broadening the view of concepts and concept teaching is that the notion will become ill-focused and lack prescriptive power. We believe that, on the contrary, a broader approach to concept learning can help bring our instructional models back into alignment with everyday teaching and learning. A continuing effort needs to be made to study strategies such as simulations, scenario-based instruction, and case studies that can help concepts come alive to beginning learners.

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Table 1

INDICATOR OF CONCEPT LEARNING	GLASNOST	SNOW LEOPARD	JUSTICE	TOTAL
Describe common attributes and related concepts	46	7	9	62
Recognize/classify/ identify/evaluate cases	6	12	20	38
Define	6	12	20	38
Give examples/nonexamples	4	10	14	28
Describe/draw	17	5	5	27
Discuss/tell someone about it	1	6	7	14
Theorize effects, implications/philosophize/predict	5	2	6	13
Differentiate from coordinate/ superordinate concepts	11	1	0	12
Relate to other concepts	3	0	6	9
Role-play	2	0	7	9
Use in sentence	1	5	0	6
Write a creative story/skit	1	1	3	5
Internalize/incorporate	0	0	3	3
Understand application varies depending on context	0	0	1	1
Explain value/importance	0	0	1	1
Understand examples	0	0	1	1